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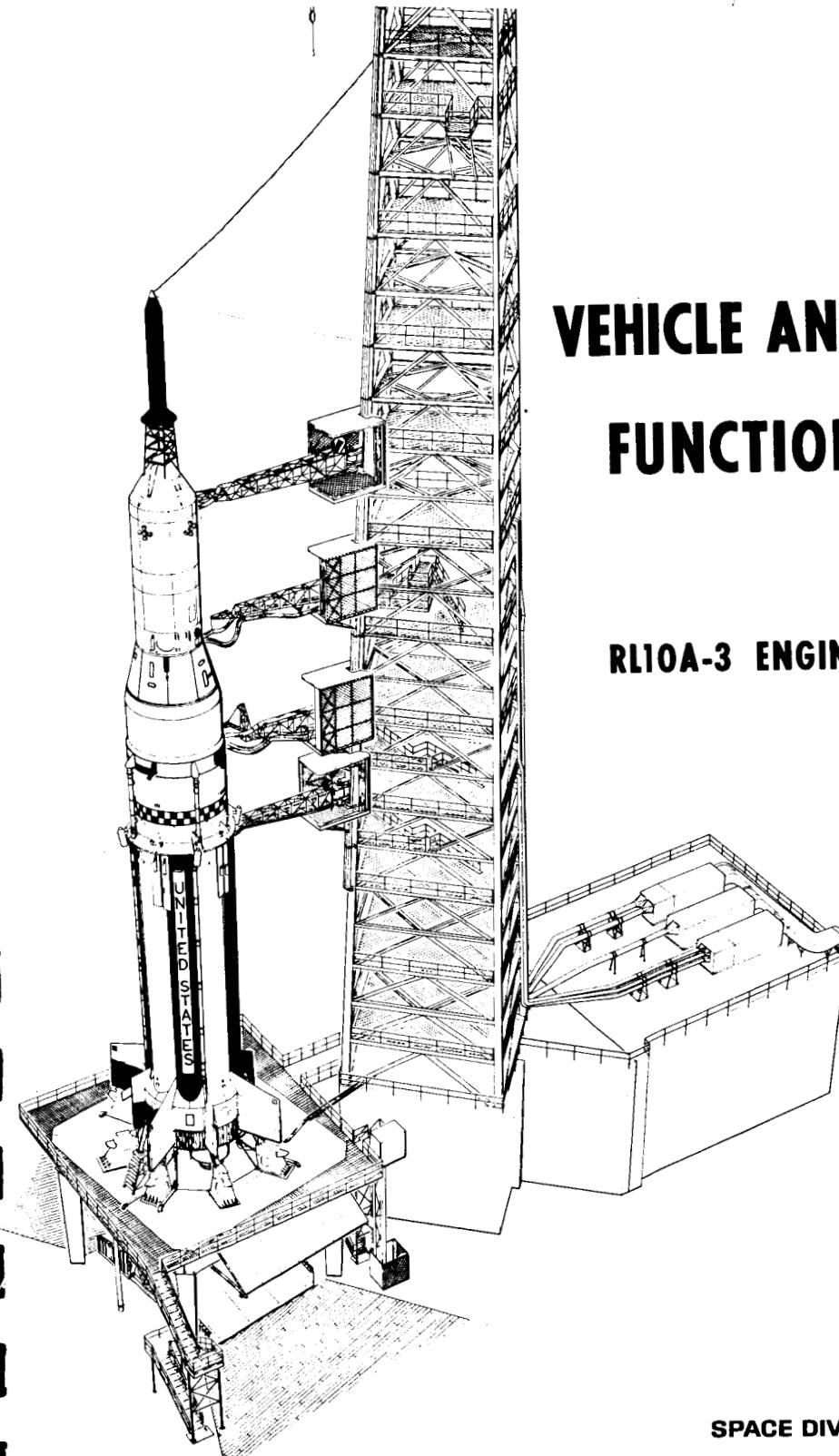
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VOLUME IX

**SA-7**

VEHICLE AND LAUNCH COMPLEX FUNCTIONAL DESCRIPTION

RL10A-3 ENGINE AND HYDRAULIC SYSTEM

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VOLUME IX

SA-7

VEHICLE AND LAUNCH COMPLEX
FUNCTIONAL DESCRIPTION

RL10A-3 ENGINE AND HYDRAULIC SYSTEM

MARCH 1964

ENGINEERING COMMUNICATIONS DEPARTMENT



HUNTSVILLE OPERATIONS

FOREWORD

This volume has been prepared for the Functional Integration Section, Systems Integration and Operations Branch, Vehicle Systems Division, Propulsion and Vehicle Engineering Laboratory, by Engineering Communications Department, Chrysler Corporation Space Division, under contract number NAS8-4016.

The following series, of which this volume is a part, functionally describes the mechanical and electromechanical systems of Saturn I, SA-7 space vehicle and Launch Complex 37:

- Volume I. RP-1 Fuel System
- Volume II. LOX System
- Volume III. LH₂ System
- Volume IV. Nitrogen and Helium Storage Facility
- Volume V. Pneumatic Distribution System
- Volume VI. Environmental Control System
- Volume VII. Launch Pad Accessories
- Volume VIII. H-1 Engine and Hydraulic System
- Volume IX. RL10A-3 Engine and Hydraulic System
- Volume X. Separation and Flight Termination Systems
- Volume XI. Supplement: Legend and Composite Schematic

Each volume contains mechanical schematics and a list of applicable finding numbers.

Volume IX describes those components that are active during countdown, launch, and flight. It is intended for use by NASA and prime contractor management and administrative personnel. Only information available by January 1, 1964 has been included.

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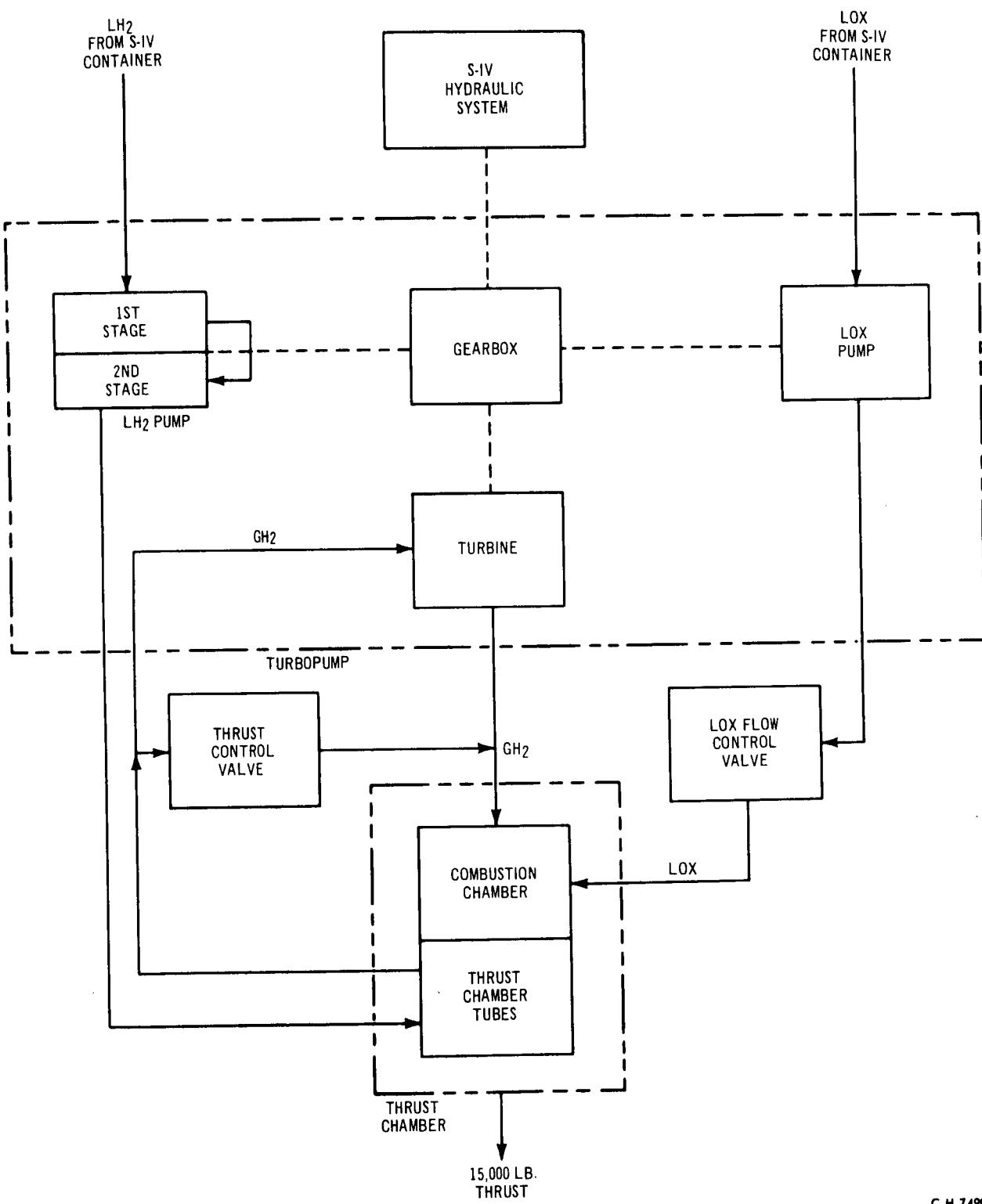


FIGURE 1. RL10A-3 ENGINE BLOCK DIAGRAM

1. RL10A-3 ENGINE

Six RL10A-3 rocket engines, producing 90,000 pounds total thrust, power the Saturn I, Block II, S-IV Stage. A single pressurized LOX container and a single pressurized LH₂ container store and supply propellant to all engines. The engines are mounted to the S-IV Stage thrust structure in a circular configuration, each at an outward angle of 6 degrees from the vehicle longitudinal axis. Each engine may be gimbaled ± 4 degrees in pitch and yaw for vehicle attitude and roll control. Should one engine fail during S-IV powered flight, the remaining operable engines will provide sufficient thrust and maintain vehicle trajectory.

Figure 1 represents propellant flow through the basic engine components-- a thrust chamber and a turbopump that consists of a two-stage liquid hydrogen pump, a LOX pump, a gearbox, and a gas turbine. The RL10A-3 features a regeneratively-cooled thrust chamber and a turbopump-fed propellant system. LH₂ flowing through the thrust chamber tubes cools the thrust chamber walls, absorbs heat, vaporizes, and drives the turbopump by means of the gas turbine.

Normal engine operation consists of LH₂ prestart, LOX prestart, start, mainstage, and shutdown. During LH₂ prestart, LH₂ flows through and cools the two fuel pump stages and discharges overboard through the interstage and downstream fuel-pump cooldown valves. During LOX prestart, LOX flows through and cools the LOX pump and continues downstream through the LOX flow control valve bypass to the combustion chamber. The LH₂ and LOX pumps must reach the prescribed temperature by the end of the LH₂ and LOX cooldown periods to prevent pump cavitation during engine start. The LOX flow control valve and LOX injector must also be cooled to the prescribed temperature to prevent GOX buildup during engine start. When LOX and LH₂ prestart terminates, ignition occurs, combustion chamber temperature rises, the turbopump accelerates, and engine thrust builds up. During mainstage, the thrust control valve allows GH₂ to bypass the turbine in proportion to thrust chamber pressure. The propellant utilization plug in the LOX flow control valve controls the LOX-LH₂ mixture ratio by varying the LOX flow to the thrust chamber. The control positioner, mounted on the LOX flow control valve, positions the plug in accordance with electrical signals from the S-IV Stage propellant utilization system, thus providing nearly simultaneous LH₂ and LOX depletion at S-IV engine shutdown. The engines shut down when an electrical signal from the engine-out pressure switches closes the start and prestart solenoid valves.

Figure 2, page 21, represents one of the engines and should be used, in conjunction with the text, to follow the various flow routes of engine operation.

1.1. Fuel Injector Purge

This purge prevents contamination of the fuel injector and thrust chamber prior to vehicle launch. When the control pressure spheres (described in Volume V) are pressurized to 1500 psig, the purge begins. On launch day, when fill pressure increases to 3000 psig, the purge flow rate increases. Helium flows from Valve Panel A (described in Volume V) through Coupling Half E200, Check Valves E282 and E44, and Orifice E37 to a ring line that distributes the Helium to each engine fuel injector. Helium flows through Orifice E334, Check Valve E332, and the fuel injector; into the combustion chamber; and out Thrust Chamber E52 nozzle on each engine. Check Valve E332 prevents GH₂ from backing up into the purge line during engine operation. The purge terminates at liftoff when the S-IV umbilical housing disconnects.

1.2. LH₂ Prestart

A signal from the guidance computer opens Fuel Prestart Solenoid Valve E36, allowing Helium control pressure to open Fuel Inlet Shutoff Valve E1. (Pressure Switch E337 sends a telemetry signal to GSE indicating that Valve E36 is open.) Fuel flows through Fuel Pump First Stage E2, after which a portion bleeds off through Interstage Cooldown Valve E3 into the hydrogen vent manifold. The remainder of the cooldown flow continues through Fuel Pump Second Stage E4 and discharges into the hydrogen vent manifold through Downstream Cooldown Valve E5.

1.3. LOX Prestart

The guidance computer signals for LOX Prestart Solenoid Valve E45 to open, allowing 455-psig Helium control pressure to open LOX Inlet Shutoff Valve E21. (Pressure Switch E331 sends a telemetry signal to GSE indicating the open position of Valve E45.) LOX pressure at the pump inlet opens Igniter GOX Supply Valve E24 through a sensing line. LOX flows through LOX Pump E22 into LOX Flow Control Valve E23. A portion of the LOX flows through the fixed bleed passages in the inlet poppet of LOX Flow Control Valve E23; the rest of the LOX bypasses the poppet and flows through the cooldown flow regulator of Valve E23, which maintains constant LOX flow during LOX prestart. Both portions of cooldown flow pass through the flow control outlet of Valve E23 into the LOX injector feed line. A portion of the LOX goes through the Igniter GOX Supply Valve E24 to the annular passage around the Spark Igniter E53 center electrode. The main flow passes through the LOX injector manifold, through the injector nozzles, and into the thrust chamber. GN₂ from the LOX-SOX Vaporization System (described in Volume V) on the S-I Stage ensures that the LOX flowing from the thrust chamber will completely vaporize before stage separation.

1.4. Start

Upon termination of chilldown, a start signal from the guidance computer initiates the start sequence. Start Solenoid Valve E38 opens to allow 455-psig Helium control pressure to move fuel pump Interstage Cooldown Valve E3

and Downstream Cooldown Valve E5 to their partially closed (bleed) positions. (Pressure Switch E339 sends a telemetry signal to GSE indicating that Valve E38 is open.) Control pressure opens Main Fuel Shutoff Valve E9 to allow fuel flow through Orifice E43, which isolates the fuel pump from pressure surges.

Fuel flows through Thrust Chamber E52 down-tubes and up-tubes, Venturi E6, Turbine Rotor E7, and Main Fuel Shutoff Valve E9. GH₂ then flows into the combustion chamber and the annulus around Spark Igniter E53. The fuel flowing around the annulus and the LOX flowing from the GOX igniter supply line form a combustible mixture that the igniter center electrode ignites. Flame propagates across the combustion chamber, igniting LOX and fuel flowing from the injector nozzles.

Heat is transferred through the combustion-chamber inner wall and adds energy to the fuel flowing in the thrust chamber tubes. The resultant high pressure GH₂ rapidly accelerates the turbine.

As turbine speed increases, LOX pump and fuel pump discharge pressures increase, causing the following valve actions:

- a. LOX Flow Control Valve E23 opens to the fully open position.
(Poppet stop has been preset for desired LOX flow.)
- b. Igniter GOX Supply Valve E24 closes.
- c. Interstage Cooldown Valve E3 closes completely when the fuel pump first stage discharge pressure reaches 150 psig.
- d. Downstream Cooldown Valve E5 closes completely when the fuel pump second stage discharge pressure reaches 330 psig.

1.5. Mainstage

During the 470 seconds that the engines operate at full thrust, Helium at 455 psig from Regulator E206 pressurizes Gearbox E54 through Orifice E329. Relief Valve E51 maintains 18 to 25 psig GN₂ gearbox pressure. GH₂ bled from the fuel injector inlet line through Valve E39 provides fuel container pressure. Differential pressure between the injector inlet pressure-sensing line and the gearbox pressure-sensing line acts on Valve E39 to maintain the proper flow rate to the container (described in Volume III).

Under ideal stage operating conditions, the engines would consume LOX and LH₂ at rates that would cause simultaneous LOX and LH₂ depletion. However, in actual operation, variations in stage tank pressures and in LH₂ and LOX flow make continuous measurement of stage depletion rates and adjustment of LOX flow necessary to ensure simultaneous depletion. LOX and LH₂ liquid level sensors in the S-IV containers provide level input signals to the propellant utilization system, which controls the position of the propellant utilization plug in LOX Flow Control Valve E23. If LOX consumption lags proportional fuel consumption for example, the propellant utilization system signals the control

positioner, which opens the propellant utilization plug in proportion to the LOX consumption lag and increases LOX flow. The propellant utilization system maintains the LOX-to-LH₂ mixture ratio within a range of 4.5 to 5.5:1.

Thrust Control Valve E8, mounted on the turbopump housing, controls engine thrust by regulating the amount of GH₂ that bypasses Turbine Rotor E7. The bypass valve in Thrust Control Valve E8 controls turbine power, which establishes total LH₂ flow, chamber pressure, and thrust. Internal valve-body pressure escapes through a line connecting the valve to the H₂ vent duct. Because Venturi E6 restricts flow before and during mainstage operation, servo pressure that bleeds off upstream of Venturi E6 and is applied to Thrust Control Valve E8 does not fluctuate with downstream pressure.

1.6. Shutdown

A fuel level probe arms the all-engine-cutoff relay at ignition +450 seconds. When main LOX discharge line pressure drops to 247 psig, Pressure Switches E55 and E56 deactuate, taking power off Start and Prestart Valves E36, E38, and E45 on all six engines. Helium vents from all valve actuators, causing the following valve actions:

- a. Fuel and LOX Inlet Shutoff Valves E1 and E21 close, shutting off LH₂ and LOX flow into the pumps.
- b. Interstage and Downstream Cooldown Valves E3 and E5 open rapidly, venting GH₂ from the fuel pump, thrust chamber jacket, turbine, etc.
- c. Main Fuel Shutoff Valve E9 closes; GH₂ downstream of the main fuel shutoff valve vents through the fuel injector.

The normally closed, main flow poppet in LOX Flow Control Valve E23 closes as LOX pump discharge pressure decreases. LOX and LOX vapor downstream of the LOX inlet shutoff valve vent through the cooldown bleed regulator in the LOX flow control valve, through the LOX injector, and out into the combustion chamber.

2. RL10A-3 HYDRAULIC SYSTEM

The six engine gimbaling hydraulic systems, one on each of the RL10A-3 engines, are the means of vehicle attitude and roll control. Each independent, closed loop system consists of:

- a. Two identical servoactuators, each of which contains a servovalve and an actuator piston rod assembly. The servovalve diverts the hydraulic fluid to either side of the actuator piston, causing the actuator rod to extend or retract, thus gimbaling the engine.

- b. A hydraulic reservoir assembly, which stores low pressure (61 psig) hydraulic fluid.
- c. A hydraulic accumulator-reservoir assembly, which contains a high pressure accumulator cylinder assembly and a low pressure fluid reservoir assembly. The high pressure accumulator piston pressurizes the hydraulic fluid within the cylinder to supply fluid to the servoactuators for engine prepositioning before S-IV ignition. This piston establishes system low pressure (61 psig) by pressurizing the fluid acting upon the piston in the low pressure fluid reservoir assembly.
- d. A main pump, which supplies 2950 psig hydraulic fluid to the system during flight.
- e. A motor-driven auxiliary pump which supplies 2950 psig hydraulic fluid to the system during prelaunch hydraulic system operation.
- f. A main pump manifold and an auxiliary pump manifold, which provide mounts for the pumps and which provide high and low pressure passages for monitoring devices, filters, bleed valves, and check valves.

Figure 3, page 23, represents one of the six identical hydraulic systems and should be used, in conjunction with the text, to follow the various flow routes of hydraulic system operation.

2.1. Fill

Prior to the hydraulic fluid fill operation, a portable GN₂ hand truck fills the GN₂ portion of Accumulator-Cylinder Assembly E109 with a 2100-psig GN₂ precharge through a hose assembly and High Pressure Nipple E70.

After this precharge has been completed, an electrical signal actuates the closing solenoid of Sequence Valve E76. High-pressure hydraulic fluid flows from a hydraulic servicer through High Pressure Coupling Half E63, Check Valve E347, and Filter E67.

Fill flow from the filter follows two major routes from a cross in Hydraulic-Accumulator-Reservoir Assembly (HARA) E338. One path leads through Check Valve E78, which cracks at a lower pressure than Check Valve E77, to Accumulator-Cylinder Assembly E109. The high pressure fluid forces the accumulator piston to compress the 2100-psig GN₂ precharge to approximately 3000 psig. High pressure fluid then flows to port A of closed Sequence Valve E76. The other path leads to Check Valve E77 and port B of closed Sequence Valve E76.

Fluid also flows to Servoactuator Assembly E110 through the high-pressure line between HARA E338 and Hydraulic Reservoir Assembly (HRA) E354 and to Servoactuator Assembly E341 from the same HARA manifold passage.

High-pressure hydraulic fluid fills all open passages and cavities within the hydraulic system. High Pressure Relief Valve E89 provides overpressurization relief by allowing flow into Low Pressure Reservoir-Manifold E108 and Reservoir E354. Bleed Valves E80, E81, E84, E87, and E88 provide escape routes for trapped air and outlets where fluid-contamination samples can be taken.

Low-pressure return fluid from Servoactuator Assemblies E110 and E341 fills HRA E354 and Low Pressure Reservoir-Manifold E108. The piston in Reservoir E108 establishes return pressure at 61 psig by means of a 49:1 difference between the piston surface areas in Reservoir E108 and Accumulator E109. Low pressure, Balanced Relief Valves E68 and E66, which crack at 110 psig, prevent overpressurization of Reservoir E108. As long as the differential pressure between the inlet and outlet of Valve E68 remains greater than 10 psig, fluid will flow through the valves at .02 gpm. Since both Valve E66 and E68 poppets vent to atmosphere, the forces which help the poppet springs hold the valves closed are balanced. Low-pressure return fluid flows back to the hydraulic servicer through Coupling Half E64.

When closed, manually-operated Prefiltration Valve E112 permits flushing of the system without exposing Servo Valve E74 components to contaminated fluid by connecting the Servoactuator high-pressure passage to the low-pressure passage. Manually-operated Cylinder-Bypass Valve E90 connects ports A and D of Servo Valve E74, thus allowing manual actuator-rod movement when necessary.

2.2. Prelaunch

Motor-Driven Auxiliary Pump E96 supplies 2950 psig hydraulic fluid to the hydraulic system during prelaunch gimbaling and checkout. Fluid flows from the pump outlet through Check Valve E93, Filter E94, and Check Valve E91 to a tee connecting Main and Auxiliary Manifolds E65 and E111 to HARA E338. Check Valve E62 prevents high-pressure fluid from entering Main Pump E61 outlet during prelaunch operations; thus, the high-pressure fluid flows through Filter E67 in the HARA, through Check Valve E77, and into Servoactuators E110 and E341. (See 2.3 for the operation of Servo Valve E74 and Servoactuators E110 and E341.) Return fluid at 61 psig flows through the low-pressure line that connects the HRA to Reservoir-Manifold Assembly E108. Low-pressure fluid also flows to Main Pump Manifold E65 through a low-pressure interconnecting line and flows to Auxiliary Pump Manifold E111, through Filter E92, and into Pump E96 inlet. Thermal Switch E83, located on HRA E354, shuts off the pump motor when hydraulic fluid temperature within HRA E354 exceeds 175°F.

When hydraulic system prelaunch operations are completed, the closing solenoid signal is removed from Sequence Valve E76. The 2950 psig pressure in Accumulator E109 holds the valve closed during flight.

2.3. Flight

An electrical signal actuates the opening solenoid of Sequence Valve E76 0.85 second after separation, allowing pressurized flow to Servo Valves E74 for engine prepositioning prior to ignition. Fluid from Accumulator E109 flows into port A and out port B of open Sequence Valve E76 to Servoactuators

E110 and E341. Upon command, the servovalves divert pressurized fluid to the proper side of the pistons in Servoactuators E110 and E341. This action extends or retracts the actuator rods, positioning the engines in accordance with guidance computer signals.

After engine start, 2950 psig hydraulic fluid flow to Actuator Assemblies E69 and E79 comes from Main Pump E61, through Check Valve E62, through Manifold E65, through a high-pressure line to Filter E67, and through the filter to the cross in HARA E338. (Main Pump E61, driven by Gearbox E54, is mounted to Accessory Drive Pad E333 on the engine turbopump.) From one branch in this cross, excess fluid vents into Reservoir E108 and HRA E354 through High Pressure Relief Valve E89. From another branch, fluid pressurizes Accumulator E109 through Check Valve E78. Accumulator E109 dampens system pressure surges during flight and, should system pressure drop to between 1000 to 2900 psig, provides a partially-redundant, fluid pressure supply.

The normal path of high pressure fluid from Filter E67 is through Check Valve E77, Prefiltration Valve E112 in Servoactuator Assemblies E341 and E110, Filter E85, port B of Servo Valve E74, and Orifices E348. From Orifices E348, fluid flows through First Stage Nozzles E345, causing a pressure buildup on each end of Power Spool E335.

When Torque Motor E343 receives an electrical signal from the guidance computer, Flapper E346 moves toward one of the Nozzles E345: the polarity of the signal determines the direction of flapper movement. Movement of the flapper changes the distance between the flapper surface and Nozzles E345, thus restricting flow causing a differential pressure between the piston ends of Spool E335. The difference in pressure slides the spool, allowing high-pressure fluid to flow through ports A or D and extend or retract the actuator rod. Relief Valve E75 opens when pressure within the actuator rod housing exceeds 10 psig.

Differential-Pressure Feedback Unit (DPF) E342 dampens gain peaking under dynamic conditions. (The DPF does not function during static conditions.) Because the pressure at each DPF piston outer end (through Port A or D) is equal to the pressure in either actuator chamber, the DPF piston will seek a new equilibrium position, thus causing a differential pressure across Nozzles E344. Fluid flow through one of the Nozzles E344 acts against Flapper E346, thus providing a feedback force proportional to the actuator force. Low pressure fluid returning from Servo Valve E74 flows through port C and through Prefiltration Valve E112 to HRA E354.

2.4. Monitoring Devices

The following transducers, gages, switches, and potentiometers transmit system conditions to GSE:

- a. Low pressure Transducer E336 (return pressure in Manifold E65)
- b. High pressure Transducer E349 (system pressure in Manifold E65)

- c. Temperature Transducer E340 (fluid temperature in the low-pressure side of Manifold E65)
- d. Temperature Transducer E86 (fluid temperature in HRA E365)
- e. High pressure Transducer E82 (GN₂ pressure in Accumulator-Cylinder Assembly E109)
- f. Pressure Gage and Switch Assembly E71 (GN₂ pressure in Accumulator-Cylinder Assembly E109, during prelaunch operations only)
- g. Pressure Transducers E95 (differential pressures acting on Servoactuators E110 and E341)
- h. Piston-Position Potentiometer E73 (fluid level in Reservoir E108)
- i. Feedback Potentiometers E72 (piston position in Servoactuators E341 and E110)

LIST OF FINDING NUMBERS

FINDING NUMBER	NO. REQD	COMPONENT	REMARKS	VENDOR	DRAWING NUMBER	ELEC SYM
E1	6	Valve, Ball, Pneumatic	2-position, shutoff	Pratt Whitney PN 2053427		
E2	6	First-Stage, LH ₂ Pump	7 in. dia., 2.158 in. high 12 blades	Pratt Whitney PN 2046928		
E3	6	Valve, Sleeve	3-position	Pratt Whitney PN 2062086		
E4	6	Second-Stage, LH ₂ Pump	7.010 in. dia., 2.0 in. high, 12 blades	Pratt Whitney PN 2029676		
E5	6	Valve, Sleeve	3-position	Pratt Whitney PN 2062087		
E6	6	Venturi, Convergent-Divergent	1.156 in. throat dia.	Pratt Whitney PN 2053239		
E7	6	Rotor, Turbine, Impulse	2-stage, partial admission, delivers 592 HP @ 28,400 rpm	Pratt Whitney PN 2037934		
E8	6	Servovalve, Flow Control	GH ₂ bypass regulator	Pratt Whitney PN 2069870		
E9	6	Valve, Bullet	5.85 lb/sec flow rate, 2-position, shutoff	Pratt Whitney PN 2064010		
E10 through E20 are not functionally applicable to this system.						
E21	6	Valve, Ball, Pneumatic	2-position, shutoff	Pratt Whitney PN 2053426		
E22	6	Pump, Centrifugal	3.965 in. dia., 1.320 in. high, 6 blades	Pratt Whitney PN 2054182		

FINDING NUMBER	NO. REQD	COMPONENT	REMARKS	VENDOR	DRAWING NUMBER	ELEC SYM
E23-1	1	Poppet and Orifice Valve Assembly	Flow rate 29.3 lb/sec	Pratt Whitney PN 2059356		401A3A2
E23-2	1	Poppet and Orifice Valve Assembly	Flow rate 29.3 lb/sec	Pratt Whitney PN 2059356		402A3A2
E23-3	1	Poppet and Orifice Valve Assembly	Flow rate 29.3 lb/sec	Pratt Whitney PN 2059356		403A3A2
E23-4	1	Poppet and Orifice Valve Assembly	Flow rate 29.3 lb/sec	Pratt Whitney PN 2059356		404A3A2
E23-5	1	Poppet and Orifice Valve Assembly	Flow rate 29.3 lb/sec	Pratt Whitney PN 2059356		405A3A2
E23-6	1	Poppet and Orifice Valve Assembly	Flow rate 29.3 lb/sec	Pratt Whitney PN 2059356		406A3A2
E24	6	Valve, Poppet	LOX and GOX	Pratt Whitney PN 2056226		
E25 through E35 are not functionally applicable to this system.						
E36-1	1	Valve, Solenoid	3-way, 2-position actuation 450 psig He	Pratt Whitney PN 2059413		401A3L1
E36-2	1	Valve, Solenoid	3-way, 2-position actuation 450 psig He	Pratt Whitney PN 2059413		402A3L1
E36-3	1	Valve, Solenoid	3-way, 2-position actuation 450 psig He	Pratt Whitney PN 2059413		403A3L1
E36-4	1	Valve, Solenoid	3-way, 2-position actuation 450 psig He	Pratt Whitney PN 2059413		404A3L1

FINDING NUMBER	NO. REQD	COMPONENT	REMARKS	VENDOR	DRAWING NUMBER	ELEC SYM
E36-5	1	Valve, Solenoid	3-way, 2-position actuation 450 psig He	Pratt Whitney PN 2059413		405A3L1
E36-6	1	Valve, Solenoid	3-way, 2-position actuation 450 psig He	Pratt Whitney PN 2059413		406A3L1
E37	1	Orifice	8.0 scfm @ 1500 psig 19.8 scfm @ 3000 psig	Del Mfg. Co. PN 10121		
E38-1	1	Valve, Solenoid	3-way, 2-position actuation 450 psig He	Pratt Whitney PN 2059413		401A3L2
E38-2	1	Valve, Solenoid	3-way, 2-position actuation 450 psig He	Pratt Whitney PN 2059413		402A3L2
E38-3	1	Valve, Solenoid	3-way, 2-position actuation 450 psig He	Pratt Whitney PN 2059413		403A3L2
E38-4	1	Valve, Solenoid	3-way, 2-position actuation 450 psig He	Pratt Whitney PN 2059413		404A3L2
E38-5	1	Valve, Solenoid	3-way, 2-position actuation 450 psig He	Pratt Whitney PN 2059413		405A3L2
E38-6	1	Valve, Solenoid	3-way, 2-position actuation 450 psig He	Pratt Whitney PN 2059413		405A3L2
E39	6	Valve, Poppet		Pratt Whitney PN 2073293		
E40 through E42 are not functionally applicable to this system.						
E43	6	Orifice	0.813 in. dia. Δ p @ 5:1 mixture 78.4 psia Δ p @ 5:1 ratio	Pratt Whitney Part of 2036709		

FINDING NUMBER	NO. REQD	COMPONENT	REMARKS	VENDOR	DRAWING NUMBER	ELEC SYM
E44	1	Valve, Check		Douglas Aircraft PN 7851843-501		
E45-1	1	Valve, Solenoid	3-way, 2-position actuation 450 psig He	Pratt Whitney PN 2059413		401A3L3
E45-2	1	Valve, Solenoid	3-way, 2-position actuation 450 psig He	Pratt Whitney PN 2059413		402A3L3
E45-3	1	Valve, Solenoid	3-way, 2-position actuation 450 psig He	Pratt Whitney PN 2059413		403A3L3
E45-4	1	Valve, Solenoid	3-way, 2-position actuation 450 psig He	Pratt Whitney PN 2059413		404A3L3
E45-5	1	Valve, Solenoid	3-way, 2-position actuation 450 psig He	Pratt Whitney PN 2059413		405A3L3
E45-6	1	Valve, Solenoid	3-way, 2-position actuation 450 psig He	Pratt Whitney PN 2059413		406A3L3
E46 through E50 are not functionally applicable to this system.						
E51	6	Valve, Vent and Relief	Opens @ 25 psig Closes @ 18 psig	Pratt Whitney PN 2030226		
E52	6	Thrust-Chamber		Pratt Whitney PN 2053649		
E53	6	Igniter, Spark	Recessed, center electrode air-gap type	General Lab Associates Part of 30092		
E54	6	Gearbox		Pratt Whitney PN 2041739		

FINDING NUMBER	NO. REQD	COMPONENT	REMARKS	VENDOR	DRAWING NUMBER	ELEC SYM
E55-1	1	Switch, Pressure	Actuates 307±5 psia Deactuates 262±10 psia	Douglas Aircraft PN 7871665-1		401A3S3
E55-2	1	Switch, Pressure	Actuates 307±5 psia Deactuates 262±10 psia	Douglas Aircraft PN 7871665-1		402A3S3
E55-3	1	Switch, Pressure	Actuates 307±5 psia Deactuates 262±10 psia	Douglas Aircraft PN 7871665-1		403A3S3
E55-4	1	Switch, Pressure	Actuates 307±5 psia Deactuates 262±10 psia	Douglas Aircraft PN 7871665-1		404A3S3
E55-5	1	Switch, Pressure	Actuates 307±5 psia Deactuates 262±10 psia	Douglas Aircraft PN 7871665-1		405A3S3
E55-6	1	Switch, Pressure	Actuates 307±5 psia Deactuates 262±10 psia	Douglas Aircraft PN 7871665-1		406A3S3
E56-1	1	Switch, Pressure	Actuates 307±5 psia Deactuates 262±10 psia	Douglas Aircraft PN 7871665-1		401A3S4
E56-2	1	Switch, Pressure	Actuates 307±5 psia Deactuates 262±10 psia	Douglas Aircraft PN 7871665-1		402A3S4
E56-3	1	Switch, Pressure	Actuates 307±5 psia Deactuates 262±10 psia	Douglas Aircraft PN 7871665-1		403A3S4
E56-4	1	Switch, Pressure	Actuates 307±5 psia Deactuates 262±10 psia	Douglas Aircraft PN 7871665-1		404A3S4
E56-5	1	Switch, Pressure	Actuates 307±5 psia Deactuates 262±10 psia	Douglas Aircraft PN 7871665-1		405A3S4
E56-6	1	Switch, Pressure	Actuates 307±5 psia Deactuates 262±10 psia	Douglas Aircraft PN 7871665-1		406A3S4

FINDING NUMBER	NO. REQD	COMPONENT	REMARKS	VENDOR	DRAWING NUMBER	ELEC SYM
E57			E57 through E60 are not functionally applicable to this system.			
E61	6	Pump, Constant Displacement	9-piston, 1.07 gpm @ 12,500 rpm	Vickers PN PF001R006C		
E62	6	Valve, Check	Crack 2 to 8 psig 2950 psig hyd fluid	Parker Aircraft PN H61C0665		
E63	6	Coupling-Half	2950 psig hyd fluid	E. B. Wiggins PN 26005D175D4		
E64	6	Coupling-Half	100 psig hydraulic fluid	E. B. Wiggins PN 26005D175D6		
E65	6	Manifold	2950 psig hydraulic fluid	Douglas Aircraft PN 1A39757-1		
E66	6	Valve, Relief	1.2 gpm Crack @ 110 psig max Reseat @ 80 psig min	Bertea PN 65945		
E67	6	Filter	2.0 gpm	Bertea PN 65950		
E68	6	Valve, Relief	1.2 gpm Crack @ 110 psig max Reseat @ 80 psig min	Bertea PN 65945		
E69	6	Hydraulic Actuator Assembly	GN ₂ , high and low pressure hydraulic fluid	Moog PN 17-172		
E70	6	Nipple	3000 psig GN ₂	PN MS28889-1		
E71	6	Pressure Gage and Switch Assembly	Gage 0-3000 psig Switch opens @ 2870±40 psig closes @ 2770±40 psig	Glassco Instruments PN 50014		

FINDING NUMBER	NO. REQD	COMPONENT	REMARKS	VENDOR	DRAWING NUMBER	ELEC SYM
E72	12	Potentiometer, Feedback		Moog PN 062-12526		
E73	6	Potentiometer, Piston-Position		Bertea PN 65940		
E74	12	Valve, Servo	2950 psig hydraulic fluid	Moog PN 010-28146		
E75	12	Valve, Relief	Crack @ 10 +10 - 8 psig	Moog PN 023-12275		
E76	6	Valve, Sequence		Bertea Part of 65900		
E77	6	Valve, Check	40-50 psig	Bertea PN 65921-1		
E78	6	Valve, Check	2-8 psig	Bertea PN 65920-1		
E79	6	Hydraulic Actuator Assembly		Moog PN 17-173		
E80	6	Valve, Manual	Bleed	Fluid Regulators PN 7579-S	60C27699	
E81	6	Valve, Manual	Bleed	Fluid Regulators PN 7579-S	60C27699	
E82	6	Transducer, Pressure	0-3500 psig GN ₂	Douglas Aircraft PN 7870467-561		
E83	6	Switch, Thermal	Actuates 160±8°F Deactuates 140±10°F	Texas Instruments PN 21428		

FINDING NUMBER	NO. REQD	COMPONENT	REMARKS	VENDOR	DRAWING NUMBER	ELEC SYM
E84	12	Valve, Manual	Bleed	Fluid Regulators PN 7579-S	60C27699	
E85	12	Filter	1 gpm, 3000 psig 5 micron	Moog PN 071-12536		
E86	6	Transducer, Temperature	-40 to +350 °F Dual element probe	Rosemount PN 150CG		
E87	12	Valve, Manual	Bleed	Fluid Regulators PN 7579-S	60C27699	
E88	12	Valve, Manual	Bleed	Fluid Regulators PN 7579-S	60C27699	
E89	6	Valve, Relief	1.2 gpm @ 3500 psig max Reseat @ 3100 psig min	Pneu Draulics PN 1577		
E90	12	Valve, Manual	2-way, 2-position	Moog PN 032-12636		
E91	6	Valve, Check	2950 psig hydraulic fluid	Bertea PN 59500		
E92	6	Filter Assembly	2 gpm, 5 micron 3000 psig	Purolator PN 7501510		
E93	6	Valve, Check	2950 psig hydraulic fluid	Parker A/C PN H61C0665		
E94	6	Filter Assembly	2 gpm, 5 micron, 3000 psig	Purolator PN 7501509		
E95	12	Transducer, Differential Pressure	3000 to 5000 psig hydraulic fluid	Travis Engr. PN 4-107-5000D		

FINDING NUMBER	NO. REQD	COMPONENT	REMARKS	VENDOR	DRAWING NUMBER	ELEC SYM
E96	6	Pump, Variable-Delivery	Motor-driven, .5 gpm @ 2950 psig, 11,300 rpm, 9-piston	Vickers Inc. PN AA-19563-E		
		E97 through E107	are not functionally applicable to this system.			
E108	6	Reservoir-Manifold Assembly		Bertea PN 65903-1		
E109	6	Accumulator-Cylinder Assembly		Bertea PN 65901-1		
E110	6	Servoactuator Assembly		Moog PN 010-12717		
E111	6	Manifold		Douglas Aircraft PN 1A48621-1		
E112	12	Valve, Manual	4-way, 2-piston	Moog PN 032-12637		
		E113 through E328	are not functionally applicable to this system.			
E329	6	Orifice	260 scim He	Douglas Aircraft PN 1A19281-1		
E330	6	Orifice	260 scim He	Douglas Aircraft PN 1A19281-1		
E331-1	1	Switch, Pressure	LOX prestart	Pratt Whitney PN 2057681		401A3S6
E331-2	1	Switch, Pressure	LOX prestart	Pratt Whitney PN 2057681		402A3S6

FINDING NUMBER	NO. REQD	COMPONENT	REMARKS	VENDOR	DRAWING NUMBER	ELEC SYM
E331-3	1	Switch, Pressure	LOX prestart	Pratt Whitney PN 2057681		403A3S6
E331-4	1	Switch, Pressure	LOX prestart	Pratt Whitney PN 2057681		404A3S6
E331-5	1	Switch, Pressure	LOX prestart	Pratt Whitney PN 2057681		405A3S6
E331-6	1	Switch, Pressure	LOX prestart	Pratt Whitney PN 2057681		406A3S6
E332	6	Valve, Check		Douglas Aircraft PN 7851843-501		
E333	6	Pad, Accessory Drive	Hydraulic pump drive	Pratt Whitney Part of 2041739		
E334	6	Orifice	1.2 scfm @ 250 psig 2.6 scfm @ 500 psig	Del Mfg. Co. PN 10121		
E335	12	Spool, Power		Moog Part of 010-28146		
E336	6	Transducer, Pressure	0-300 psig hyd fluid	Bourns PN 2004201903		
E337-1	1	Switch, Pressure	LH ₂ prestart	Pratt Whitney PN 2057681		401A3S1
E337-2	1	Switch, Pressure	LH ₂ prestart	Pratt Whitney PN 2057681		402A3S1
E337-3	1	Switch, Pressure	LH ₂ prestart	Pratt Whitney PN 2057681		403A3S1

FINDING NUMBER	NO. REQD	COMPONENT	REMARKS	VENDOR	DRAWING NUMBER	ELEC SYM
E337-4	1	Switch, Pressure	LH ₂ prestart	Pratt Whitney PN 2057681		404A3S1
E337-5	1	Switch, Pressure	LH ₂ prestart	Pratt Whitney PN 2057681		405A3S1
E337-6	1	Switch, Pressure	LH ₂ prestart	Pratt Whitney PN 2057681		406A3S1
E338	6	Hydraulic Accumulator Reservoir Assembly (HARA)		Bertea PN 65900		
E339-1	1	Switch, Pressure	Engine start	Pratt Whitney PN 2057681		401A3S2
E339-2	1	Switch, Pressure	Engine start	Pratt Whitney PN 2057681		402A3S2
E339-3	1	Switch, Pressure	Engine start	Pratt Whitney PN 2057681		403A3S2
E339-4	1	Switch, Pressure	Engine start	Pratt Whitney PN 2057681		404A3S2
E339-5	1	Switch, Pressure	Engine start	Pratt Whitney PN 2057681		405A3S2
E339-6	1	Switch, Pressure	Engine start	Pratt Whitney PN 2057681		406A3S2
E340	6	Transducer, Temperature	61 psig hydraulic fluid	Rosemount PN 150CG		
E341	6	Servoactuator Assembly		Moog PN 010-12717		

FINDING NUMBER	NO. REQD	COMPONENT	REMARKS	VENDOR	DRAWING NUMBER	ELEC SYM
E342	12	Unit, Feedback Dynamic-Pressure (DPF)		Moog Part of 010-28146		
E343	12	Motor, Torque		Moog Part of 010-28146		
E344	24	Nozzle, DPF		Moog Part of 010-28146		
E345	24	Nozzle		Moog Part of 010-28146		
E346	12	Flapper		Moog Part of 010-28146		
E347	6	Valve, Check	2-8 psig	Bertea PN 65920-1		
E348	24	Orifice		Moog Part of 010-28146		
E349	6	Transducer, Pressure	0-3500 psig GN2	Douglas Aircraft PN 7870467-561		
E350 through E353 are not functionally applicable to this system.						
E354	6	Hydraulic Reservoir Assembly (HRA)	61 psig return hydraulic fluid, 82 cu. in. displacement	Bertea PN 66000		

FIGURE 2. RL10A-3 ENGINE

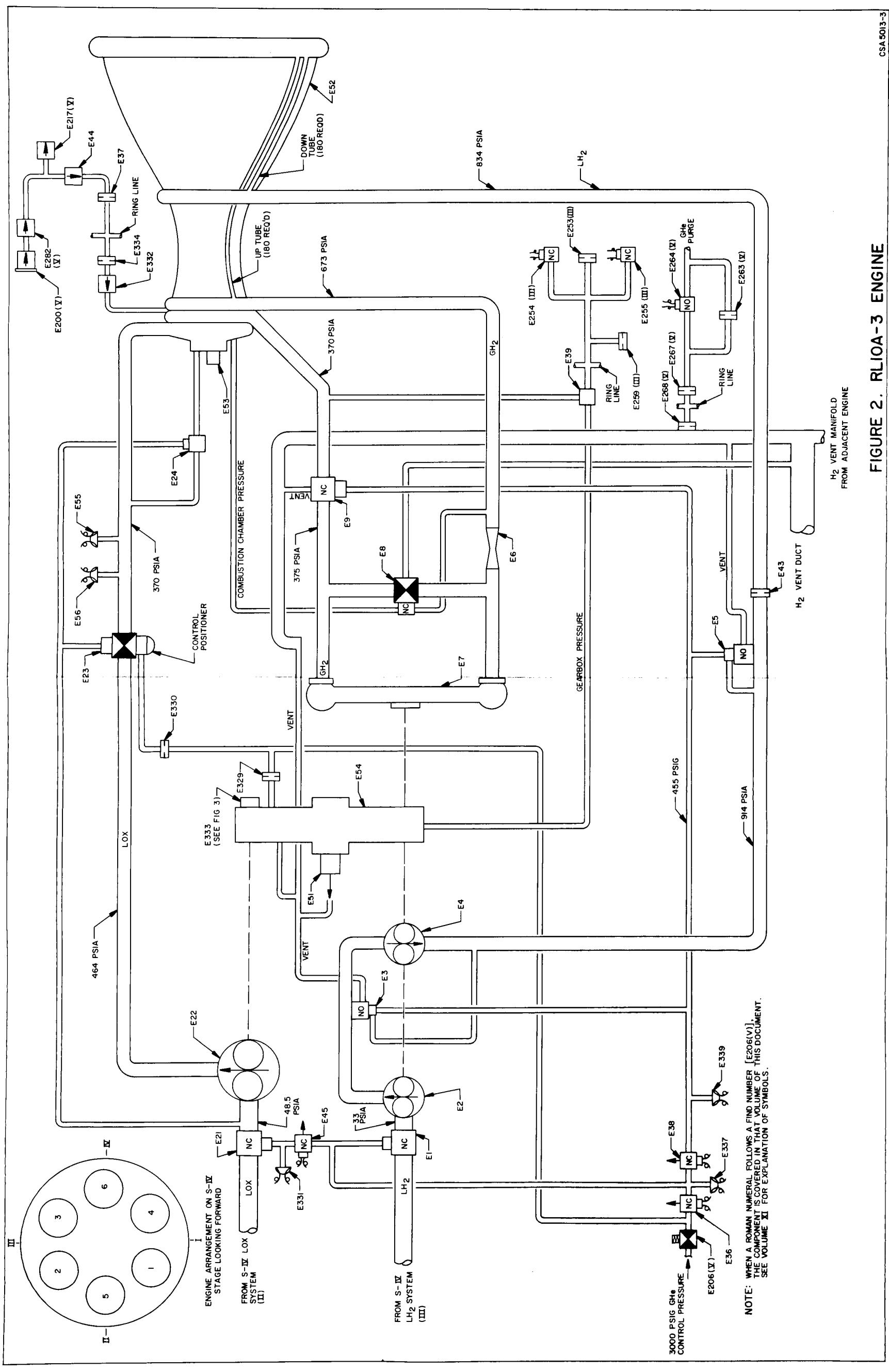
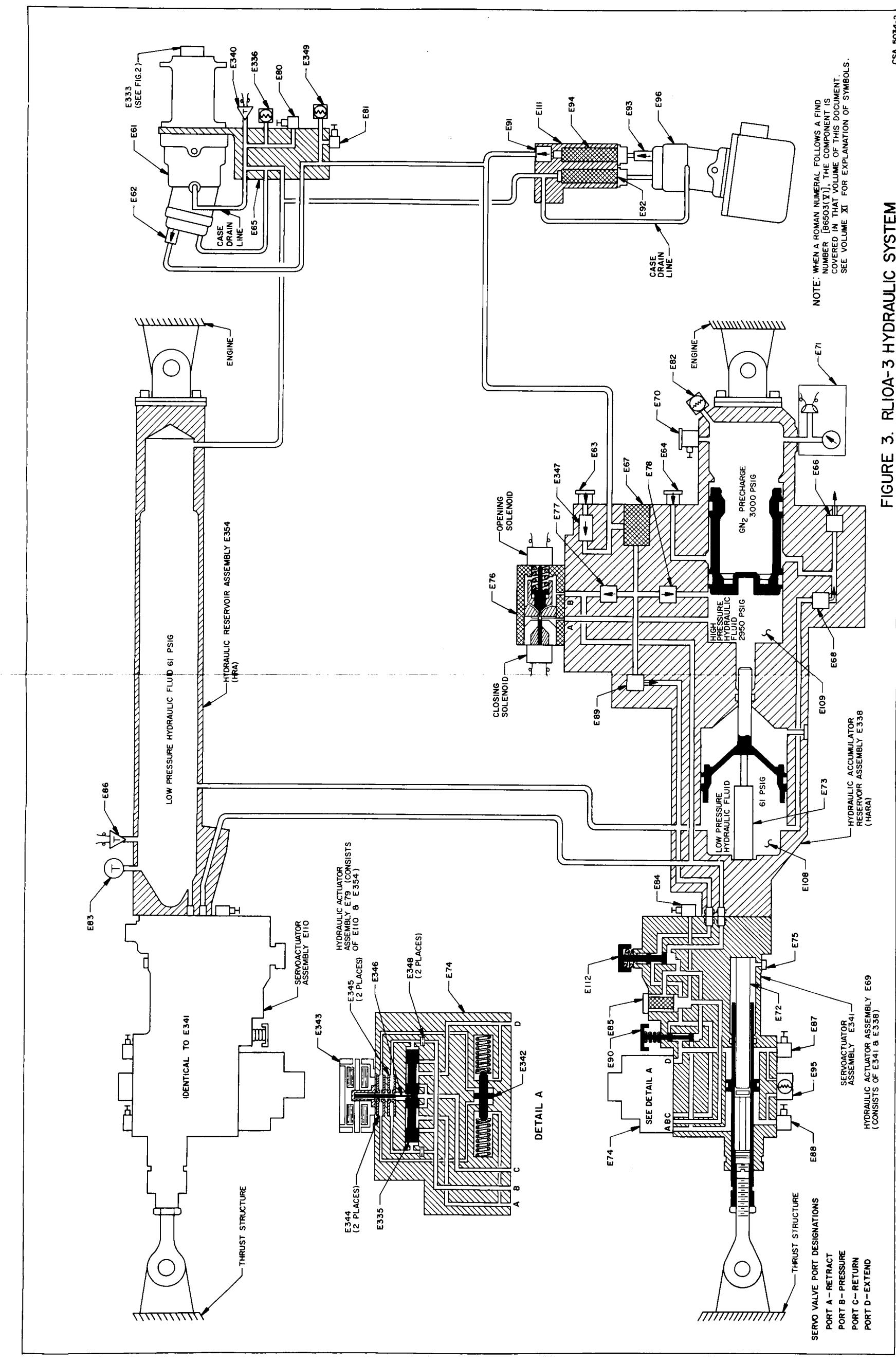


FIGURE 3. RLOA-3 HYDRAULIC SYSTEM



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